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REPORT ON INSECT INFESTATIONS AND EXPERIMENTS IN THE NEBRASKA NATIONAL FOREST DURING 1934

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REPORT ON INSECT INFESTATIONS AND EXPERIMENTS IN THE NEBRASKA NATIONAL FOREST DURING 1934

Observations and experiments on insects injurious to the pine plantations in the Bessey Division of the Nebraska National Forest near Halsey, Nebraska, during the 1934 season are discussed in the present report. The insects involved and the studies pertaining to them are listed in the table of contents.

A fairly complete analysis of the Nebraska situation was obtained again this year although part of the field season was taken up by work in other forests of Region 2. Observations in the plantations near Halsey were carried on by the writer during the following periods: June 6 to 21; June 27 to July 23: and August 24 to October 31. Besides this local work, part of the time spent in the Black Hills in late July and August was utilized to study parasites of the pine tip moths in connection with the Nebraska problem.

The outstanding features of the 1934 season were the extreme drought and record high temperatures. The excessive temperatures in July were detrimental to one of the tip moths and to the pitch moth, causing an unusual summer mortality. A record maximum temperature of 109° F., occurred on July 15, 1934, in the Weather Bureau shelter on the lawn near the office building. In the Forest Service shelter half way up the hill, located in a stand of thirty foot jack pine, but exposed to the sun part of the day, the maximum reached 113° F.

It is likely that in protected hollows in the hills and stands exposed to the sun, temperatures might have been even higher. Records for past years show that in the Weather Bureau shelter the previous high maximum was 108° F., but this is unusual and in most years the extreme is from 2° to 5° lower. Besides the record temperature on July 15th, high temperatures continued for an unusual period of several weeks in July. In May, also, a temperature of 101° F., was recorded, which is the highest for this month.

A few soil surface temperatures were taken with a centigrade thermometer on July 15th, the hottest day, between 2 P.M., and 2:25 P.M. The thermometer registered an air temperature, in the shade of the laborator, from 109° to 109.4° F., (42.8° to 43° C.). A psychrometer reading indicated the relative humidity at 13 percent. The thermometer placed on the exposed surface of the dry sandy soil in the nursery registered from 143.2° to 143.6° F. (61.8° to 62° C.). Similar high temperatures on the surface soil in the nursery have been observed before even with air temperatures several degrees lower, as on July 12 and 13, 1925, when surface temperatures were recorded at 138.2° F., and 144.5° F., respectively.

The species of tree most affected by drought in the plantations was jack pine. Groups of dead jack pine were evident in many of the plantations established in the last ten years, and occasional individuals succumbed in plantations more than twenty-years old. Norway pine suffered to a small extent but it was noted that in many cases only the upper half of the crown had died and the lower crown was

still green in late fall. Ponderosa pine apparently withstood the drought successfully, except for the current or very recent plantings where mortality was high for all species.

The developmental season was also unusually early in 1934. The first emergence of second generation tip moths (Rhyacionia frustrana bushnelli) was noted on June 13. This is more than a week earlier than any emergence date previously observed, and is three weeks ahead of the first emergence in years with a late development season.

THE PINE TIP MOTHS

The two species of tip moths will be discussed separately, with the studies pertaining to them. The first, Rhyacionia frustrana bushnelli (Busck), has two generations a year and was the original tip moth found in the plantations. This species was reduced to low numbers for a time by the introduced parasite, Campoplex frustranae Cushman. Following the discussion of bushnelli the tree plot data are presented to show the amount of infestation by this species. The second moth, Rhyacionia neomexicana (Dyar), is of rather recent occurrence in the plantations and has but a single generation annually. The introduced parasite does not affect neomexicana and at present this moth is causing serious damage, although still unevenly distributed over the plantations. Observations on distribution and injury have been limited largely to ponderosa pine, with some data on Norway or red pine, since these are the two tree species most affected.

Rhyacionia frustrana bushnelli Infestation

In 1934 the first generation of Rhyacionia bushelli was considerably more numerous than in 1933, due to the low percent of parasitism last year. This increase was evident from the abundance of moths emerging from the parasite cages as well as from the number of ponderosa pine leaders infested in the field.

Records on infested leaders indicate that bushnelli continues to be least numerous in areas where it has been competing with the second moth for several years, even though parasitism has been low. This year's counts of larvae of the two species in 100 ponderosa pine leaders at various points over the planted area show that within 1/2 mile of the nursery, where the second moth, Rhyacionia Neomexicana, has been very numerous for more than two years, R. bushnelli in two plots was infesting only 31 and 35 percent of the leaders. In plots 1 and 1½ miles from the nursery, where neomexicana has become destructive within the last two years, 47 and 43 percent of the leaders contained first generation bushnelli. While in the five plots at distances of 2½ to 4½ miles, 57 to 67 percent were infested, in areas where neomexicana has only become numerous this season or is still scarce. The age of the plantations decreases, in general, with distance from the nursery, but all plots are still of susceptible height and consequently the size of the trees would not entirely account for fewer bushnelli in the older areas. However, even though the first generation of bushnelii might be reduced to some extent by

competition with the other tip moth, as far as injury is concerned the damage resulting from the two species is as great or greater than would occur from either species alone.

The infestation by the first generation of bushnelli, with from 31 to 67 percent of ponderosa pine leaders attacked in different areas, is a serious epidemic and corresponds to the original heavy infestation by this species prior to parasite introduction. Normally with parasitism low, as it was this year, the second generation of bushnelli would cause about twice as much damage as the first. However, this did not occur in 1934 and is the first instance where a failure of the second generation, not due to parasitism, has been observed.

Summer Mortality of Rhyacionia frustrana bushnelli.

When the tip moth tree plots were checked in the fall, it was found that very few shoots had been injured by the second generation of bushnelli, contrary to expectations. In fact, the number of tips damaged were much fewer than those injured by the spring generation even though the summer flight of moths had been heavy. The only factor that accounts for the heavy mortality to the second generation is the record high temperatures in July, which have been previously discussed. The extreme temperature on July 15th, when 113° F., or over must have occurred in many of the stands of pine, was probably fatal to many of the insects and it is likely that the several weeks of continuous hot, dry weather was also detrimental. At this period

the tip moth was in the young larval stage and doubtless some of them were still feeding in the base of needles or had not penetrated the buds and shoots very far. No observations were being made on the tip moth at this particular time.

As a result of this unusual summer mortality to the second generation, many of the pine leaders remained uninjured, as will be evident in the tree plot data. A Noticeable reduction in the infestation by bushnelli should occur next year because of the small number of overwintering insects. However, under favorable conditions the infestation can be expected to build up rapidly. Although the introduced parasite was very scarce this year, the loss of large numbers of its host would tend to decrease the parasite still more.

Parasitism of Rhyacionia frustrana bushnelli

The amount of parasitism on the first generation larvae and pupae of Rhyacionia bushnelli was determined by the usual procedure of collecting and caging infested tips just prior to the emergence of the first moths in June. A total of 300 ponderosa pine tips were collected from each of eight permanent collection plots scattered across the plantations, and this year one additional collection was made in Norway pine.

The results from the rearings showed that parasitism was very light on the first generation this season. This was due to a marked scarcity of the introduced parasite, Campoplex frustranae, the native

parasites accounting for only a small percent of parasitism as usual. The average parasitism for all ponderosa pine plots was only 12 percent, a decided reduction from the 42 percent recorded in 1933. The parasitism in the single Norway pine plot was also 12 percent. This year the introduced Campoplex accounted for only 15 percent of all parasites reared, while last year 74 percent were Campoplex.

Considering separate parts of the planted area in relation to the prevalence of the second species of tip moth, Rhyacionia neomexicana, in which the introduced parasite does not develop, there is still a difference in the amount of parasitism of R. bushnelli. However, it is the reverse of what it was last year. In three plots within 1½ miles of the nursery, where neomexicana has been numerous and bushnelli less abundant for several years, parasitism of bushnelli averaged 20 percent; a slight decrease from the 29 percent last year. For the five more distant plots, 2½ to 4½ miles from the nursery where R. bushnelli has been the more important species, parasitism averaged only 8 percent this year; a marked decrease from the 48 percent recorded in 1933. As mentioned before, most of the parasitism that did occur was caused by native species this year and apparently these were a little more numerous in areas heavily infested by both tip moths.

The further decline of the introduced Campoplex parasite is difficult to explain, and with the prevalence of its host this spring, an increase could have been expected. It is possible that mild open

winters with long dry periods are detrimental to the campoplex larvae hibernating within the host cocoons in the litter and soil. Such conditions would probably characterize the past winter and certainly occurred during the winter of 1930-31 which was followed by a decided drop in the Campoplex population in all parts of the plantation. The heavy summer mortality to the host, as suggested before, probably decreased the numbers of the introduced parasite still more during the second generation. This would leave Campoplex, in point of numbers, about where it was soon after introduction except for the fact that it now occurrs in all parts of the plantations and will not have to spread from one center of colonization. The effect of the extreme heat in July on adult Campoplex that might still have been in flight at that time is not known. However, some of the host larvae were already parasitized and those that survived should provide at least a small nucleus of the introduced parasite for next year.

Tree Plot Records

Four permanent plots, three in ponderosa pine and one in Norway pine, were checked in the fall. Each plot contains about 100 trees and records were taken on total height and tip moth damage to the leaders. The 1934 data compared to past two years are presented in Table I. The height measurements include the killed portion of the leader and consequently heavy damage one year is the cause of poor height increase the following season. In the table the total percent of leaders injured by one or both species of tip moths is given to

indicate the extent of total damage. The leaders estimated to contain Rhyacionia bushnelli larvae are also listed to show the amount of damage that would have been caused by this species alone. And the last column shows the percent of additional leaders infested with R. neomexicana, other than those containing bushnelli, but this does not represent the complete neomexicana infestation as many tips contained larvae of both species.

Table I. - HEIGHT GROWTH AND PERCENT OF LEADERS INFESTED WITH TIP MOTHS IN PONDEROSA AND NORWAY PINE PLOTS, 1932 to 1934.

Year	Aver. Ht. of trees in inches	Increase Ht. over previous year	% leaders inf. by one or both species	% inf. by R. bush.	% add. inf. by R. neomexicana
		Norway Pine, Plot No. 20 (Planted 1915)			
1932	86.9	15.0	57	48	9
1933	102.0	15.1	91	68	23
1934	107.4	5.4	71	41	30
		Ponderosa Pine, Plot No. 19 (Planted 1915)			
1932	87.4	6.8	91	26	65
1933	94.5	7.1	95	28	67
1934	98.9	4.4	64	31	33
		Ponderosa Pine, Plot No. 13 (Planted 1918)			
1932	65.1	5.7	91	67	24
1933	73.9	8.8	96	62	34
1934	76.6	2.7	70	48	22
		Ponderosa Pine, Plot No. 1 (Planted 1924)			
1932	27.0	1.8	59	59	0
1933	37.2	10.2	97	96	1
1934	41.7	4.5	63	61	2

The figures on average height growth in Table I show considerably less growth increase in 1934 than in 1933. This was largely due to the serious damage to leaders in 1933, the new leaders starting below the point of injury or a lower lateral shoot taking the place of the old leader. The drought also had some influence but it was noticed that where buds were uninjured last year a fair growth was put on this season. The Norway pine plot which has maintained a height increase of 15 inches for several years, following the work of the introduced parasite, has again made poor growth as a result of increased damage by both moths in this area in 1933.

The table also shows the decrease in general infestation for 1934 and, as can be seen, this is largely accounted for by the fewer leaders infested by Rhyacionia bushnelli although R. neomexicana also declined somewhat in the older ponderosa pine plots. The decreased infestation by bushnelli is due to the heavy summer mortality from heat and not due to parasitism, as has already been discussed. Without this mortality to the second generation, the number of leaders damaged would have been fully as great as in 1933 and many of the short shoots would have been entirely destroyed.

The percent of leaders remaining uninjured this season is sufficient to influence appreciably the average height growth in 1934 and a fair height increase can be expected. From 29 to 37 percent of the leaders were not infested this year, whereas last year only 3 to 9 percent were left normal and uninjured in these plots.

Rhyacionia neomexicana Infestation

Although specimens of the second tip moth, Rhyacionia neomexicana (Dyar), were collected in the plantations in 1926, it was not until 1928 that damage caused by this species became noticeable. At that time the light infestation was confined to a small area adjacent to the nursery, in the northeast corner of the plantations. Within four years the epidemic built up to a maximum in the original restricted area and at the same time continued to spread over the plantations to the southwest and west. The amount of infestation, up until this year, decreased almost directly with distance from the nursery because of the gradual spread and multiplication of the moth. The species of pine most affected by R. neomexicana are ponderosa and Norway pine, which is also the case with the original tip moth, R. buoliana.

This year a more extensive survey of the neomexicana infestation was completed during the second week in June, when the larvae were maturing. Leaders on 100 ponderosa pine were examined at each of nine separate points in plantations. The 1934 data as compared to the previous two years are presented in Table II, showing the percent of leaders infested by neomexicana and the average number of larvae per infested leader. The first five plots are on a line running practically southwest from the west end of the nursery; the next three plots represent the west side of the planted area, the

plots located about a mile from the west edge of the plantings and 1½ miles apart; the last plot, near Planting Camp 4, is due south of the nursery. The age of the plantations where the counts were made decrease directly down the table, from a 1913 planting in the first plot above the nursery to a 1925 planting in the camp 3 area and a 1924 planting in the camp 4 area. Counts on 100 leaders gives a fair sample where the infestation is very heavy, and is usually within 5 percent of an average from 200 or more leaders; however, where the infestation is light, such a sample may vary as much as 10 or 15 percent from the real average. There was not time to take larger samples before the larvae left the tips. The 1932 counts represent 200 leaders for each plot, the 1933 and 1934 counts 100 leaders at each point.

Table II - PERCENT OF PONDEROSA PINE LEADERS INFESTED BY RHYACIONIA NEOMEXICANA AND AVERAGE NUMBER OF LARVAE PER INFESTED LEADER IN PLANTATIONS AT GIVEN DISTANCES FROM THE NURSERY. 1932-1934

Plot location	1932	1933	1934
Hill above nursery			
% leaders infested	93	87	69
No. larvae per leader	6.0	4.6	3.4
½ mile to southwest			
% leaders infested	79	88	70
No. larvae per leader	4.0	5.4	3.2
1 mile to southwest			
% leaders infested	19	45	50
No. larvae per leader	1.9	2.2	3.1
1½ miles to southwest			
% leaders infested	--	61	67
No. larvae per leader	--	2.4	3.8
2½ miles to southwest			
% leaders infested	--	--	83
No. larvae per leader	--	--	3.7
3½ miles west (Black Trail windmill)			
% leaders infested	--	--	44
No. larvae per leader	--	--	1.9
3½ miles W by SW (Meadow & Black Trail firebreaks)			
% leaders infested	--	--	21
No. larvae per leader	--	--	2.1
4½ miles southwest (south of Camp 3)			
% leaders infested	--	--	5
No. larvae per leader	--	--	1.2
3 miles south (near camp 4)			
% leaders infested	--	--	64
No. larvae per leader	--	--	2.6

The data in Table II indicate that in the oldest areas of infestation, represented by the first two plots within 1½ mile of the

nursery, the epidemic has declined appreciably from the maximum infestation in 1932 and 1933. However, the damage here is still very serious with about 70 percent of the leaders infested. In all other areas the infestation presumably continued to increase in 1934, although there are only the two plots, at 1 and 1½ miles, for comparison and here the increase was only slight. The heaviest damage this year was recorded in the plot 2½ miles southwest of the nursery, in a 1918 planting of ponderosa pine, where 83 percent of the leaders examined were infested. This area is located roughly near the center of the entire planted area. The lightest infestation occurs at greater distances near the west side of the plantations. In the northwest corner, represented by counts near the Black Trail windmill 3½ miles west of the nursery, the damage is fairly heavy with 44 percent of the leaders attacked. In the southwest corner of the plantations, 4½ miles from the nursery the damage by this moth continues to be very light, with only 5 percent of the examined leaders infested this year. To the south, at a distance of only 3 miles, near Camp 4 as shown by the last plot, the damage is already heavy in the 1924 planting examined. No counts were made in younger plantations in the Camp 4 area, some of which extend 5 miles south of the nursery but at this distance it is likely that the infestation is still very light.

To summarize the current infestation of Rhyacionia neomexicana, the damage to ponderosa pine in two zones of distance from the nursery, which is located in the northeast corner of the plantations, is estimated to be about as follows: Within a radius of 3 miles from the nursery

from 50 to 83 percent of all leaders were infested; the heaviest damage occurring at a distance of 2 to 2½ miles. In the outlying plantations 3½ to 5 miles from the nursery the damage decreased with distance varying from 44 percent down to 5 percent of the leaders infested.

It can also be noted from Table II that the number of larvae per infested leader varies almost directly with the percent of leaders infested. This means that in a heavily infested area not only are more leaders injured but the proportion of the individual leader destroyed is greater than in areas of light infestation. Three neomexicana larvae will usually destroy about one inch of the average sized leader, although occasionally this species will start feeding an inch or two below the apex rather than in the partially developed buds. The number of neomexicana larvae found in individual leaders this year varied from 1 to 14, while in previous counts as many as 24 have been recorded. Occasionally from 6 to 8 inches of the leader is riddled by the larvae, which in some instances may be the entire length, however, the average length destroyed is probably under two inches.

The extreme heat in mid July apparently had little influence on Rhyacionia neomexicana because, due to the early season, most of the larvae had already left the tips and spun cocoons beneath

the litter on the base of the trees. In this situation the single generation species was protected whereas the other species, R. bushnelli, was just starting its second generation in the tips and incurred a heavy mortality. It is possible that a few late developing neomexicana larvae were destroyed in the tips. A number of larvae were found dead in their cocoons in the first half of July, but it is believed that this was at least partly a natural mortality. A few larvae, as was also observed last year, had been attacked by a fungus after spinning their cocoons; the body becoming solid and brittle and covered with a white mycelial growth. It is not certain whether the fungus attacked the living larvae or developed after death from other causes. By early fall there was also a light mortality of the hibernating pupae, amounting to about 6 percent for the 124 normal pupae examined. If the general mortality to neomexicana was much above normal this year, it will probably be apparent in 1935, however, it appeared that the number of healthy pupae found on the base of the trees was sufficient to continue the present infestation.

Parasites of Rhyacionia neomexicana

Although a number of the native parasites attack the larvae of Rhyacionia neomexicana in the tips the percent of parasitism is consistently low. The introduced parasite Campoplex frustraneae, as has been mentioned, may deposit eggs in the young larvae but fails to develop in this species and consequently has no influence

against neomexicana. The pupae are apparently free from attack by pupal parasites because they are hidden beneath the litter in cocoons on the base of the trees. Total parasitism of the larvae was estimated to be between 10 and 15 percent. No records were obtained on the egg parasite this spring. An examination of 425 host cocoons in September and October, 1934, showed that only 8 percent contained parasites, which had destroyed the larvae before pupation--not counting a few larvae dead from other causes. In addition to this 8 percent parasitism found in the cocoons, a small number of larvae had been destroyed by other parasites before leaving the tips.

Only two species of parasites were found in the hibernating cocoons of the host. The most common was apparently one of the species of Microbracon, an external parasite of the larva. From four to eight small, tough, brownish cocoons of the parasite were found in one end of the host cocoon with the remains of the dead larva. A few of these parasites had evidently emerged before late summer but a majority remained in the larval stage and would develop and emerge next spring. This Microbracon parasite accounted for three-fourths of the 8 percent parasitism in the cocoons. The other parasite was evidently a species of Lissonota which was reared from host cocoons last spring. In October, this parasite was still in the larval stage, a single large larva occupying its thin, brownish cocoon within the host cocoon. Parasitism of neomexicana

larvae by this Lissonota was less than 2 percent.

The possibility of introducing parasites of Rhyacionia neomexicana which do not already occur in the plantations has been considered, however, in the limited work along this line no promising parasites have been discovered. Parasites have been reared from small quantities of infested tips, collected whenever possible in recent years, from the Black Hills, from around Flagstaff and Prescotto, Arizona, and from the San Juan National Forest in Southwestern Colorado. It has been found that many of the tip moth parasites in these regions are already present in the Nebraska plantations, apparently being species of wide distribution. Several other parasites were reared but they were not numerous and most of them emerged from the tip moths in the summer when this host was not again available. Such parasites must depend on other hosts for the second generation and their abundance is consequently influenced by these alternate hosts. In the Nebraska plantations parasites of this type have not been effective.

One parasite not yet found in Nebraska was reared from the overwintering cocoons of neomexicana and apparently develops a single generation on this host alone. This was a new species of Eulimneria, different from a summer emerging species present in the plantations, and occurred both in the San Juan Forest and in the Black Hills. However, the parasite was very scarce and at the time of rearing at least was of little importance. The heavy

Rhyacionia neomexicana infestation in natural ponderosa pine reproduction in the San Juan Forest, on Piedra Mesa, has been visited several times in the last seven years and it is evident that in this period neither the Eulimneria species nor other native parasites have been able to reduce the epidemic appreciably.

This season additional observations were made on tip moth parasites in the Black Hills in late July and August, along with other work. The two moths present in Nebraska are also native in the Black Hills although Rhyacionia frustrana bushnelli has but a single generation in that region. R. neomexicana is far more numerous at present than it was in 1926, when the tip moths were previously investigated, and this may account for the increased damage apparent in many localities in the Hills.

At the time of the first observations on July 24, 1934, it was found that many of the larvae had already left the tips, due to the early season. A few parasite cocoons were obtained in the infested tips but these were scarce. A larger collection of material was made from the neomexicana cocoons on the base of the trees, for rearing and identification next spring of overwintering parasites. An examination of this material in early fall indicated that at least two species of parasites would pass the winter in the host cocoons, however, these appeared to be the same two species of Microbracon and Lissonota as were found in cocoons in the Nebraska

plantations. The parasite larvae considered to be those of Lissonota were somewhat more numerous than was recorded in the plantations and it is possible that climatic conditions in Nebraska are less favorable to this parasite. The species of Eulimneria previously recorded from the Black Hills was not identified but many of the specimens were not disturbed for an examination and the tentative determinations of the parasites from the larval stage and the cocoons need to be confirmed from reared adults.

A small predacious beetle larva was also found feeding on the larvae and pupae of neomexicana in the cocoons. This beetle was found in less than 2 percent of the cocoons examined and evidently was of minor importance. Such a predator would, of course, destroy the overwintering parasites as readily as the hibernating stages of the tip moth.

These additional observations on parasites of Rhyacionia neomexicana are not very encouraging from the standpoint of obtaining suitable species for introduction into the plantations of the Nebraska National Forest. It is also questionable if the success obtained for a time with the introduced Campoplex parasite against the original tip moth can again be duplicated. However, the possibility of obtaining parasites which might be of some benefit has by no means been exhausted by the limited studies along this line. It is likely that not all of the parasites have been reared or that certain species were at a low stage at the time of collection.

The success of an introduced parasite cannot be predicted entirely on its status in natural stands of timber. Tip moth damage in the plantations is heavier and more consistent than in many stands of natural reproduction. This is no doubt partly due to higher parasitism by the same species in natural stands, especially where alternate parasite hosts are involved. Such seemed to be the case in native timber in northern Nebraska, where, from collections one season, parasitism was considerably higher than in the plantations although the parasites were practically the same. However, it seems that this does not fully account for the very light infestation in some areas of native timber. Other factors such as the scattered timber, uneven aged stands, and possibly native predatory insects, may have an influence on the amount of tip moth damage. It was noted in the Black Hills this summer that the tip moths were very destructive in some localities while in other areas the injury was almost negligible. The part that parasites might have played in this uneven distribution, or the other numerous factors that might have been involved could only be determined definitely by a prolonged investigation. It appears that conditions found in natural timber would not necessarily be reproduced in the Nebraska plantations by duplicating the parasite fauna. However, there is still a chance that useful parasites might be found and colonized in Nebraska with some success under the present conditions of heavy Rhyacionia neomexicana infestation.

Aside from indigenous parasites on Rhyacionia neomexicana, it was suggested by Dr. Craighead that European parasites introduced for the European pine shoot moth, R. buoliana, in northeastern United States be considered for their possibilities in Nebraska. Correspondence with the gipsy moth laboratory at Melrose Highlands, Mass., brought out the fact that due to the difference in the life history of the two moths, the European species passing the winter in the tips as a partially grown larva, most of the parasites would not be well adapted to neomexicana. Consequently, the use of European parasites was not attempted, although if other species are introduced, which emerge at the proper season and might develop successfully on neomexicana, colonization of such species should be considered.

Spraying for Rhyacionia neomexicana pupae

Observations last year showed that the larvae of Rhyacionia neomexicana, when mature in late June and July, crawl down the hole of the tree and spin their cocoons in the bark crevices near the ground line, beneath the litter. Pupation occurs about ten days later and the pupae remain in the cocoons until the following spring. Thus far this is the only place that the pupae of this species has been found and presumably most, if not all, hibernate on the base of the trees. A few preliminary experiments were conducted this season to test the effect on the pupae from spraying certain materials

around the bole near the ground line. This type of spraying would not affect the other tip moth, R. bushnelli, since this species apparently drops from the tips and spins up in the litter or soil away from the bole.

Two materials which act as fumigants were tested in the experiments: carbon disulphide, using a 50 percent emulsion which was diluted to give from 1 to 10 percent solutions of carbon disulphide; and Orthene (orthodichlorobenzene), used undiluted and diluted to a 16.6 percent solution in soapy water. Because of the difference in the size of the trees the amount of solution was varied according to the diameter, from one-half to 2 ounces being applied for each inch of basal diameter in different tests. The sprays were applied during two periods to test the effect of summer and fall applications. The summer spraying was conducted on July 12, 18 and 20, when temperatures varied from 91° to 106° F., at the time of application. By mid-July this year, practically all of the larvae had pupated. The fall spraying was done on September 28 and 19 and October 5, with temperatures of 72° to 83° F. Five to ten trees, with a basal diameter of one to five inches, were used in each test. With half the trees the solution was sprayed on and the amount estimated, while with the other half the material was measured out and poured around the base ~~on~~ as a check on the amount applied by spraying.

Examination of the July sprayed trees was made in September and the September spraying was checked in late October. Unsprayed trees were examined at the same time to determine the natural mortality. The pupae were removed from all cocoons that could be located and the number dead and alive recorded. There was no difference in the appearance of live and dead pupae, but after sufficient mechanical stimulation the live specimens would become active. On many of the trees very few cocoons were found, in fact the data in some tests is so meager that definite conclusions cannot be drawn. The number of pupae found and the mortality from the different strengths and quantities of spray are presented in Table III.

TABLE III - MORTALITY TO RHYACIONIA FRUSTRICANA PUPAE IN COCOONS ON BASE OF PONDEROSA PINE SPRAYED WITH CARBON DISULPHIDE AND ORTHENE, AS COMPARED TO MORTALITY ON UNSPRAYED TREES.

Spray material	Strength of spray	No.oz.per inch diam.	No.life pupae	No.dead pupae	Percent mortality
		Summer spraying - July			
Check - untreated			44	1	2.2
CS_2	1%	1	27	0	0
"	8.3%	1	7	30	81
"	8.3%	2	0	6	100
Orthene	16.6%	1	1	5	83.3
"	16.6%	2	9	3	25
		Fall Spraying - Sept. & Oct.			
Check - untreated			74	5	6.3
CS_2	5%	2	17	9	34.6
"	10%	½	4	7	63.6
"	10%	1	10	6	37.5
"	10%	2	4	14	77.8
Orthene	100%	1	0	20	100
"	100%	2	0	16	100
"	100%	2*	3	27	90

*In litter around tree.

The results shown in Table III are not very consistent as to the amount of spray material applied, due apparently in some cases

to the small number of insects involved. However, some general conclusions can be drawn from these preliminary experiments. It appears that a 10 percent solution of carbon disulphide applied at the rate of two ounces for each inch of basal diameter of the tree will give a good kill of the pupae. It also appears that the summer spraying with this material gave a little better control than fall spraying. No damage to the trees was evident by late fall.

Orthene diluted to a 16.6 percent solution apparently is not very effective--the results from using one and two ounces per inch of diameter being inconsistent and the sample of insects too small. Undiluted Orthene is apt to injure the cambium, however, the bases of a few trees were sprayed in October to determine the effects. A complete kill of pupae was obtained with both one and two ounces where applied directly on the tree. Where applied in the litter around the tree, avoiding wetting the bark as much as possible, a 90 percent kill of pupae was recorded. The influence on the trees will not be apparent until next summer but this material is probably too injurious to use in undiluted form directly on the trees.

As to the effect of the sprays on the parasites hibernating in the tip moth cocoons: the carbon disulphide at strengths used did not kill the parasites; the 16.6 percent Orthene killed part and the undiluted Orthene killed all of the parasites. The carbon disulphide seems to be the most promising material to use against the pupae of Rhyacionia neomexicana when considered from all angles.

The experiments also indicate that to obtain suitable samples of pupae, a larger number and more heavily infested trees should be used in similar spray tests.

THE PITCH MOTH

Observations on the pitch moth, Dioryctria ponderosae Dyar, in 1934, were limited to examinations to determine the summer mortality, a check of the tree plots for records on the current infestation, and a continuation of spraying experiments with Orthene. These items will be discussed under separate headings.

Summer Mortality of Pitch Moth

An examination of pitch moth burrows under the bark in September showed that a heavy mortality had occurred during the period of extremely high temperatures in mid-July, when the insects were in the mature larval and pupal stages. A total of 71 burrows were examined in Scotch pine and Austrian pine and in 75 percent of these, or 53 burrows, the insects were located, either the dead specimens or the empty pupal skin which indicated normal emergence of the moths in late July and August. The mortality for the 53 specimens found was 40 percent. This is an unusually high mortality for the advanced stages and apparently was due directly to heat. Last year the mortality recorded for 200 insects in August was only 6 percent which is probably near normal for maturing stages.

Pitch Moth Infestation

The annual examination of six pitch moth plots was made in September to record the number of attacks for the season, as indicated by pitch masses on the bark. All plots showed a decided decrease in the infestation from last year, and this is the second consecutive season that a natural reduction has occurred.

The data since 1932 for three of the more heavily infested plots, in Scotch pine, Austrian pine and ponderosa pine, are presented in Table IV to show the continued decrease in number of attacks the last two seasons. In the Scotch and Austrian pine plots the 1932 figures represent the infestation remaining after control cutting operations in the winter of 1931-32 which reduced the infestation about 50 percent from that recorded in 1931. In addition in the Austrian pine plot, five infested trees were cut the following winter, but this does not account for full reduction in number of attacks in 1933. The remaining decrease in the total number of trees in these plots is due mostly to improvement cuttings in these stands, with only two trees girdled and killed by the pitch moth in 1934. No infested trees were cut in the ponderosa pine which is less susceptible to attack. However, all Peridermium galls were removed during the winter of 1933-34 in this plantation and one tree was cut because of heavy infection. Many of these Peridermium galls were infested with the pitch moth, but no continuous records of such attacks have been made because of the difficulty of determining the year infested

and the number of larvae present in the galls. The infestation shown for the ponderosa pine plot is concerned only with primary attacks on the bole or at a whorl of branches.

Table IV shows the percent of trees infested, the total number of attacks in the plot, and in index of infestation. This "Infestation Index" is the average number of attacks for 100 trees and serves as a unit or comparable figure for the variable number of trees in the plots.

Table IV - PERCENT OF TREES INFESTED AND NUMBER OF PITCH MOTH ATTACKS IN PLOTS OF SCOTCH, AUSTRIAN AND PONDEROSA PINE, 1932-1934

Year	No. trees in Plot	% trees infested	Total No. attacks	Infestation index
	Scotch Pine (1913 planting) Plot S-S.P.			
1932	305	16.1	142	46.5
1933	295	10.8	86	29.2
1934	293	4.8	29	9.9
	Austrian Pine (1914 planting) Plot 2-A.P.			
1932	178	22.5	90	50.6
1933	172	16.6	69	40.1
1934	171	5.8	16	9.4
	Ponderosa Pine (1913 planting) Plot 1-P.P.			
1932	200	10.5	39	19.5
1933	200	9.0	26	13.0
1934	199	2.5	5	2.5

The reduction in the pitch moth infestation was greated in 1934 than in 1933, as is indicated by the plots in Table IV. The

decrease in infestation in 1934 amounted to 66 percent in the Scotch pine; 75 percent in the Austrian pine; and 81 percent in the ponderosa pine plot.

The three other pitch moth plots, not shown in the table, were established in a 1910 planting of Scotch pine following the cutting of heavily infested trees and the thinning of most of the stand. The purpose of these plots was to follow the infestation in thinned and pruned areas as compared to an unthinned portion of the plantation. The light infestation that remained in these plots has also dropped off since 1932. By 1933 one of the plots was free from attacks and the other two plots had only two and three trees lightly infested. In 1934 not a single fresh attack was found, all trees in these plots apparently being entirely free from infestation. This particular Scotch pine plantation as a whole has very little pitch moth injury at the present time.

The marked decrease in the infestation shown in the plots this season does not include the summer mortality to the pitch moth since the damage occurred prior to this mortality and these attacks were counted. Consequently, the total decrease in the pitch moth population is even greater than that indicated in Table IV. The reason for the natural decline in number of attacks in 1934 is not clear. There was no prolonged period of extremely cold weather during the winter, such as occurred the previous year and was considered the cause of the reduced infestation in 1933. The lowest temperature the past winter was -23° F. on February 25th, followed the succeed-

ing night with - 15° F. Similar low temperatures were recorded in 1929 with -27° and -15° F. on February 15th and 19th, but from limited data available this was evidently followed by an increased infestation. Consequently freezing may not have been a factor this year and it is possible that other factors during the fall or early spring might have had an influence on the small larvae hibernating under the bark scales.

No control cutting to remove heavily infested trees was carried out in the vicinity of the pitch moth plots the past winter, although cutting was conducted by the Forest Service in one other Scotch pine plantation not previously treated. It was suggested that no additional cutting of infested trees be made during the winter of 1934-35 because of the very light infestation. With the few attacks occurring this season followed by a high summer mortality, it is likely that many of the previously infested trees contain none of the small, hibernating larvae and the cutting of such trees would not assist in reducing the infestation further. The artificial control measures since 1929 combined with the natural reduction in infestation the last two seasons have left the pitch moth at a lower stage in the plantations than at any time in the last eight or ten years.

Spraying Pitch Moth Attacks

The experimental spraying of pitch moth attacks with Orthene (orthodichlorobenzene) was continued on a small scale in 1934. However, because of the summer mortality to this insect from heat the results are not very conclusive. The tests in 1933 indicated that

undiluted Orthene killed about 60 percent of the larvae and pupae but caused injury to the cambium of the trees in many cases; a 16.6 percent solution of Orthene destroyed approximately 45 percent of the insects and apparently caused no cambium injury. In the diluted spray last season one part of linseed oil was added to four parts of Orthene before diluting with soapy water, since this appeared to make the emulsion much more stable. This year the linseed oil was not used in the mixture and a stronger diluted solution, 25 percent Orthene, was tested. The spray was mixed in the following proportions: One part Orthene, three parts water and 1/32 part laundry soap. In such a mixture the Orthene separates from the water in a very short time, but the spray tank was shaken before each application of spray to maintain an even dilution. A three-gallon, pressure spray tank was used, as last year, and the pitch mass and surrounding bark thoroughly wetted.

Pitch moth attacks on thirteen Scotch pine and four Austrian pine were sprayed on July 21, 1934, with air temperatures ranging from 95° to 106° F. Examination of the burrows was made in September; the number of dead insects, empty pupal skins indicating normal emergence, and missing insects were recorded for all sprayed attacks that appeared to be normal. The results were as follows:

Total number of attacks considered normal - 66.
Percent of attacks where insects were found - 71% (47 insects)
Percent of attacks where insects were missing - 29% (19 insects)
Percent of recovered insects dead - 72% (18 larvae, 16 pupae).
Percent of insects dead and missing - 80% (53 insects).

In unsprayed trees out of 71 attacks, as discussed under summer mortality, 40 percent of the recovered insects were dead; 25 percent were missing or not located; 55 percent were dead and missing. Four percent more insects were missing in the sprayed than in the unsprayed trees and as noted last year some of the larvae were probably driven from their burrows by the fumigant.

Based on the number of insects recovered, with 72 percent dead in sprayed trees and 40 percent normally dead in the check trees, the treatment destroyed 32 percent of the insects. Considering 4 percent additional driven from their burrows the effectiveness of the spray was 36 percent.

However, on the basis of total number of insects dead and missing, which was 80 percent in treated and 55 percent in untreated trees, the spray was only 25 percent effective.

These records would indicate that the 25 percent solution of Orthene in soapy water only killed between 25 and 36 percent of the pitch moth larvae and pupae. This is less than the 45 percent kill estimated last year for a weaker, 16.6 percent solution with the linseed oil added. It is not believed that the small amount of linseed oil made the difference but rather than the high mortality from heat varied considerably in different trees thus making the comparison between sprayed and unsprayed trees inaccurate. The 1934 spraying experiments, therefore, should be considered as not being conclusive.

No cambium injury was noted from the 25 percent solution of Orthene but to test this strength several trees of different species were sprayed, wetting about two-thirds of the length of the bole. The effect on the trees, if any, will not be apparent until next spring. Spraying with undiluted Orthene in a similar manner last year on two Scotch pine, one Austrian pine and one jack pine resulted in the death of all these trees. However, one jack pine with the bole sprayed with a 16.6 percent solution was apparently not affected and made normal growth this season. It is evident that undiluted Orthene cannot be safely used on these pine trees. A dilution of one to five, giving a 16.6 percent solution of Orthene, and probably stronger mixtures, apparently will cause no injury to the trees. The 16.6 percent Orthene gave about 45 percent control of the pitch moth, which is only a little less than the control obtained by cutting out the heavily infested trees in 1932.

Woodpecker Work

In 1932 a small amount of woodpecker work was noted on a few Scotch pine trees for the first time, as has been previously reported. This may have been caused by migrating birds since no woodpeckers were observed in the plantations during that summer. In 1933 a hairy woodpecker was observed and heard drumming near the nursery on numerous occasions during the summer and apparently spent the full season in the vicinity. Only one specimen was seen although it is possible that a pair might have nested in some of the old willow stubs along

the river. No particular woodpecker work was noted in the pitch moth infested trees that season.

During the summer of 1934, a woodpecker was again heard on several occasions. In the examination of pitch moth infested trees in the fall holes were found in the bark around pitch moth attacks on a number of Scotch pine trees scattered over the older plantations. This was undoubtedly the work of a woodpecker. It was not evident, however, that many of the insects had been found before the moths emerged although a few were probably destroyed. Some of the burrows were apparently old and some were opened at several points, indicating that the bird did not locate the insects in every instance. The number of pitch moths actually destroyed was probably far less than the scattered woodpecker work might indicate. The observations show that the woodpecker will search the pitch moth burrows, at least after the pitch has dried and at this time might find some of the pupae before emergence of the moth. It could not be determined from the fall examination whether or not some of the work might have been done while the insect was still in the larval stage and the pitch still flowing. The edges of the burrows of the pitch moth, Dioryctria ponderosae, are sometimes infested by the other pitch moth, D. abietella, which is of minor importance, and it is possible that some of the woodpecker work was due to the presence of the latter species which can be found in all stages of development during the season. No woodpecker work occurred on the trees included in the plots and consequently did not affect this season's counts.

WHITE GRUB EXPERIMENTS

The experiments with lead arsenate treated soil in the nursery, as related to the effect on trees, were continued in 1934 in cooperation with the Forest Service. Arsenic injury occurred again the second season. Since the white grubs were scarce in the nursery no experiments were attempted with the insects themselves. Besides the lead arsenate plots an area treated with crude arsenic in 1930 was used for transplanting this year and the stock was injured. The effect of these two treatments on the trees will be discussed separately.

Lead Arsenate Plots

Three adjoining plots in Block III of the nursery were treated in the spring of 1933 with lead arsenate at the rate of 500 pounds, 1000 pounds and 1500 pounds, respectively, per acre. The material was spread on the surface and disced in to a depth of 3 or 4 inches. Both2-1 and 1-1 pine transplants and 2-1 juniper or red cedar were grown in this soil during the season. As discussed in last year's report, the 2-1 stock from the lightest dosage of 500 pounds suffered a mortality 3½ to 4 times the normal, and a greater loss from the heavier dosages; while the loss to the 1-1 stock was almost complete, indicating that susceptibility to arsenic injury varied with age of the stock and the dosage applied.

These trees were dug by the Forest Service in the early spring of 1934 and the entire section, including the treated plots, was

utilized for 1-1 juniper (Juniperus virginiana). The original depth distribution of the lead arsenate was changed by the spring plowing and some of the arsenic soil must have been turned under to a depth of 6 or 8 inches. The usual leveling of the beds with a heavy flat drag and the work in digging the trees apparently intermixed some of the soil in these adjacent plots and may account for the fact that the mortality this season was not consistent with the dosage. An irregular line of good trees at the end of the plots also indicated some shifting of the arsenic soil. At the edge of the outside bed where new soil had evidently been turned in by the plow the trees made a fairly normal growth, and even within the treated beds there were spots where trees were nearly normal. There appeared to be no influence from the arsenic outside the treated area other than that which could be attributed to plowing and leveling.

In addition to the above three plots, a new plot was treated by nurseryman Dayhersh in the spring of 1934, using a lighter dosage of 400 pounds of lead arsenate per acre. This plot joined one end of the previous plots and was planted with the same species.

Counts on survival of the 1-1 juniper, after one season in the treated soil, were made in October. One thousand trees were examined in the center of each plot across three of the beds, not including the outside bed because of the new soil at the edge. The mortality recorded for the different dosages of lead arsenate

applied in 1933 and 1934 as compared to mortality in untreated soil was as follows:

Check plot, untreated - Mortality 6%.
500# per acre, treated in 1933 - mortality 80%.
1000# per acre, treated in 1933 - mortality 82%.
1500# per acre, treated in 1933 - mortality 71%.
400# per acre, treated in 1934 - mortality 4%.

The data show the serious effects of lead arsenate the second season in the soil, at the 500 pound dosage and over. In addition to the 71 to 82 percent mortality in the 1933 treated plots, many of the surviving trees were in poor condition and it is likely that additional loss will occur before digging next spring. Most of the trees were severely stunted and made very little height growth during the season in arsenic soil. Figure 1 shows the appearance of one of the treated beds compared to untreated beds. No 1-1 juniper was used in the 1933 experiments and since older stock is less susceptible, a direct comparison of mortality for the first and second year of arsenic in the soil cannot be made.

The new plot treated in 1934 with 400 pounds of lead arsenate per acre showed no loss above the normal mortality. The growth and appearance of the trees were also normal and evidently this lighter dosage had no influence the first season. The lead arsenate used was held over from the supply of the previous year and it is uncertain if any appreciable deterioration in strength might have occurred in this time. However, under these conditions, it is evident that there is considerable difference between the 400 pound

dosage, which caused no injury to 1-1 juniper the first season, and the 500 pound dosage which last year damaged to some extent the older 2-1 juniper. It is possible that next year more of the arsenic will be soluble and thus available to the trees and that the 400 pound dosage will then cause injury.

An examination was also made of the root systems on some of the surviving trees in the heavily damaged, 500 pound per acre plot as well as on trees in untreated soil. To obtain a complete root system the trees were washed from the soil with a hose. It was found that the roots were severely stunted and comparatively little new root growth had been put on since transplanting in the treated soil. Some of the roots were traced below the depth of lead arsenate distribution but apparently roots at this depth had also failed to develop normally. Figure 2 shows the stunted character of both tops and roots of 1-1 juniper of average size from treated as compared to untreated soil.

To determine whether the nursery soil was acid or alkaline, nurseryman Dayharsh made several analyses with a pH testing outfit. In untreated soil two tests showed a pH of 7.3 and 7.4. In soil treated the previous year with 1000 pounds of lead arsenate per acre the pH was recorded at 7.3 and 7.6. In soil treated with crude arsenic in 1930, as discussed below, four tests at different points this season gave a range on the pH scale from 6.9 to 7.4. Since pH 7 is neutral it is apparent that a condition approximating neutrality exists in the soil.

Crude Arsenic Plots

In 1930 the Forest Service treated an area in Block III of the nursery with crude white arsenic at 80 pounds per acre, by mixing and spreading with manure before spring plowing, to test this material for white grub control. As it happened, this was the worst white grub year in the history of the nursery and the main infestation was in the section where the arsenic had been applied. The experiment proved successfully that crude arsenic was not effective since thousands of transplants were destroyed by the grubs both in the treated and untreated soil. There was no apparent arsenic damage to the 2-1 ponderosa pine transplants, or at least if some injury did occur, it wasobscured by the heavy grub damage.

This section of the nursery was left idle during the next three years but in the spring of 1934 was again utilized for 1-1 ponderosa pine and 1-1 jack pine. By early summer a light discoloration of the needle tips became apparent in the treated area. By late summer the tips of most of the needles, sometimes half the length of the needle, had turned red and the whole area was heavily discolored. The mortality to trees in the treated soil was somewhat above normal, jack pine being most susceptible to arsenic injury. Records from the regular Forest Service nursery counts in the fall showed the following losses:

1-1 Ponderosa pine in untreated soil - mortality 8.1%.
1-1 Ponderosa pine in arsenic soil - mortality 12.4%
1-1 jack pine in untreated soil - mortality 10.0%.
1-1 jack pine in arsenic soil - mortality 26.3%.

In addition to this mortality and the killing of the ends of the needles, the trees in treated soil had both the tops and roots stunted asmuch as 25 and 50 percent. Figures 3 and 4 show the extent of this stunting from arsenic as compared to growth on normal trees.

In this experiment arsenic was causing injury four year after being applied, or during the fifth season in the soil. It appears that the injury was greater in 1934 then in 1930, although the older stock used in 1930 may partially account for the apparent lack of arsenic damage that year. That arsenic in the soil will continue to be injurious for a period of years is evident.

Samples of 1-1 ponderosa pine and 1-1 jack pine from the soil treated with crude white arsenic in 1930 and from untreated soil in the same nursery section were sent to Washington by the Forest Service in July, 1934, for an analysis of the arsenic content in these trees. Determinations were made of the arsenic content in the roots and in the needles, recorded in parts per million on a dry basis. It was stated that the samples were oven-dried for six hours at 110° C. before taking the weights for analysis. The results were as follows:

	Parts As_2O_3 per million (dry basis)	
Soil	Roots	Needles
Untreated soil	5.1	8.3
Arsenic treated soil	25.0	61.1

From the condition of the trees in treated soil, it is evident that 1-1 ponderosa pine and jack pine with an average arsenic content shown above will be effected under Nebraska conditions about as

follows: the average mortality will be about twice the normal mortality, the ends of most of the needles will be killed, and the trees will be stunted from 25 to 50 percent. The jack pine suffered a greater loss than the ponderosa but whether or not this was due to a higher arsenic content in the jack pine is not known because the two species were not analized separately.

GRASSHOPPER INFESTATION

The grasshopper situation was investigated upon arrival at Halsey in early June, the field examinations being made with the Forest Supervisor and Ranger. In the area covered by the current plantings, young grasshoppers were numerous and the situation appeared similar to that of the last few years with prospects of serious damage to the youngest plantations during the summer. In the 1932 plantings where control was carried on two years ago, the insect population had again built up to dangerous numbers. However, in the area treated last year, covering the 1933 plantations, examinations at a number of points showed that the grasshoppers were relatively scarce. Apparently the control work last season in early July destroyed a large percent of the insects and prevented extensive egg laying in this area, and evidently few grasshoppers had migrated into the 850 acres treated from the surrounding territory.

With conditions favorable for serious grasshopper damage in the current plantations and the possibility of some injury in the 1932 plantings, the Forest Service again carried on control work, as had

been done in the previous three seasons. According to the Supervisor's insect report, 24,000 pounds of the poisoned bran-sawdust mixture being distributed by the Bureau of Entomology was obtained. Amyl acetate and salo were added to the commercial bait since these materials had been used previously with good results. Approximately 1,000 acres were treated during the last half of June with the use of C.C.C. labor, covering the current plantations and a part of the 1932 plantings.

There was no opportunity to make actual counts on the grasshopper population to determine the effectiveness of control. However, since a heavy application of bait was made and the spreading done only during the most favorable feeding hours, it is believed that the treatment was equally as effective as in previous seasons. Grasshoppers will probably be scarce in this area next year, according to past experience in the Nebraska National Forest.

Whether the record high temperatures in July had any influence on grasshoppers was not determined. It is possible the same mortality occurred, however, the possible need for control next season cannot be predicted at this time.

THE SCALE INSECT

Two private jack pine plantations outside the Forest, the Lewellyn plantation at Thedford, and the Beckhoff plantation nine miles northeast of Thedford, Nebraska, were examined in company with Supervisor Van Giesen on October 26th. A serious infestation of

the scale insect, Toumeyella numismaticum, existed in these plantations several years ago, and even following spraying by the State Forester in 1929 considerable numbers of the scale remained. This year only one live specimen of the scale insect was found, in the Beckhoff plantation, after a number of trees were examined. It is evident that the insect has been reduced to insignificant numbers by natural agencies. It is also likely that enough insects remain in both plantations to continue the infestations which may again become serious in more favorable years.

On October 29, 1934, examinations were made, with the Supervisor and Ranger Newcomer, of the eight small areas in the plantations of the Forest where jack pine infested with the scale insect had been cut in 1928 and 1929. A few specimens of the scale have been found and destroyed around several of these areas since the original control work. This year none of the insects were found on the trees examined. Some of the plantations had been pruned, making it difficult to inspect many of the branches, however, the general appearance of the trees indicated that there was at least no heavy infestation in this vicinity. Considering the scarcity of the scale insect in the private plantations the prospects of locating the few scattered insects that might remain in the Forest were slight.

BARK BEETLES

Attacks by the red turpentine beetle, Dendroctonus valens, were found at the base of many of the older scattered jack pine

killed by drought. In most cases the beetle galleries, extending below the ground line, did not completely girdle the tree. It appears, as last year, that these beetles entered the weak and dying pine and were not the primary cause of their death. Other dead jackpine were found that were entirely free from beetle attacks. This beetle has not been found in ponderosa pine in the plantations and apparently is not infesting healthy trees at the present time. Several attacks have been observed at the base of normal appearing Scotch pine but it was found in these cases that the beetles had been overcome or driven out by the copious flow of pitch.

The single species of Ips known to occur in the plantations, Ips grandicollis, continues to be very scarce. It was found in only a couple of the dying or dead jack pine trees although these should have made favorable host material.

TREE INJECTION EXPERIMENT

Impregnating of green jack pine with a solution of bichloride of mercury was tested on a small scale in October. Because of the small size of the trees, it was possible to set the base in the solution which was absorbed in the process of transpiration.

Three separate dosages were used: 1/2 ounce, 1 ounce and 2 ounces of bichloride of mercury dissolved in 2 quarts of water. Six unpruned jack pine, varying from 3.8 to 6 inches d.b.h., and from 22 to 30 feet in height, were used for the injection of each

dosage. The base was pruned, the tree cut and propped up against adjacent trees and the butt immediately placed in a two-gallon stone jar containing the chemical. The 2 quarts of solution were absorbed within from 3 to 8 hours for different trees. A day or two later these poles were pruned and cut into 7 foot posts which were piled in the open with the bark on. An equal number of posts were also cut from untreated trees. The slash from the different treatments was placed in separate piles, in case later information should be desired on the rate of deterioration.

Since no wood boring insects attacking felled trees above ground occur in the plantations, no information will be obtained on the prevention of such attacks. It is not likely that any Ips were attracted to these unpeeled posts becauseof the scarcity of the insect and the time of year. However, a native termite causes considerable damage to posts in the soil. If the treated posts can be peeled and placed in a test fence or a test plot next season the influence of the chemical on termite attacks can be followed. These posts would also serve as a test for bichloride of mercury as a wood preservative in jack pine under Nebraska conditions.

EXPLANATION OF PLATE I.

Figure 1. Nursery beds containing 1-1 juniper during 1934 season. Bed in foreground, with dead and stunted trees, has soil treated with lead arsenate at 1000 pounds per acre in 1933. Beds in background are normal, soil not treated. Bessey nursery, Nebraska National Forest, October, 1934.

Figure 2. Equal number of 1-1 juniper of average size from untreated soil (on left) and from soil treated with lead arsenate at 500 pounds per acre the previous year. Showing by comparison the stunted condition of the tops and roots after one season in treated soil. Scale shown is marked off in inches. September, 1934.

PLATE I.

Fig. 1

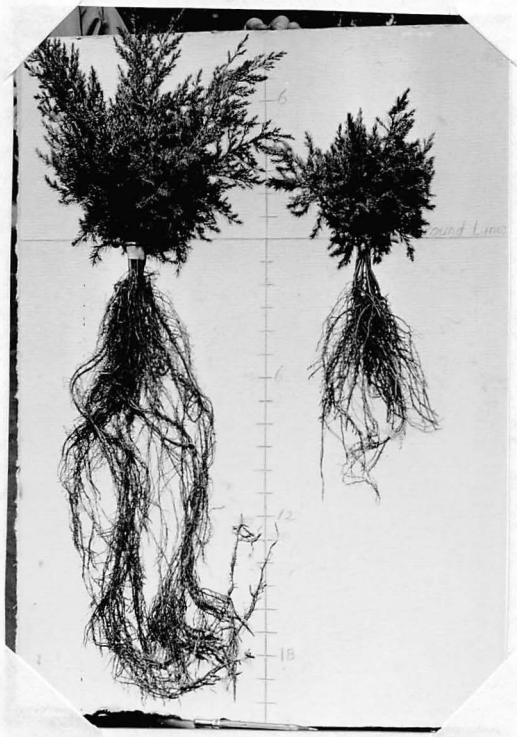

Fig. 2

EXPLANATION OF PLATE II

Figure 3. Equal number of 1-1 ponderosa pine of average size from untreated soil (on left) and from soil treated with crude white arsenic at 60 pounds per acre in 1930. Showing by comparison the effect of arsenic on trees four years after soil was treated--trees one season in treated soil. Scale shown is marked in inches. September, 1934.

Figure 4. Equal number of 1-1 jack pine of average size from untreated soil (on right) and from soil treated with crude white arsenic at 60 pounds per acre in 1930. Showing by comparison the stunting effect of the arsenic four years after the soil was treated--trees one season in treated soil. Scale shown is marked off in inches. September, 1934.

PLATE II

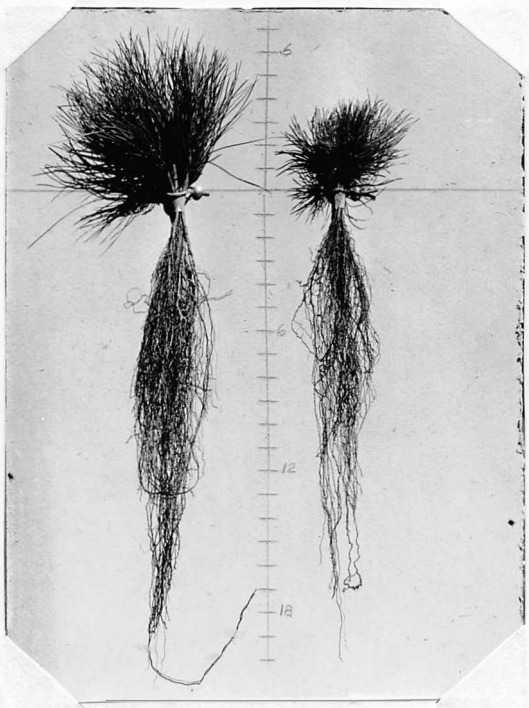

Fig. 3

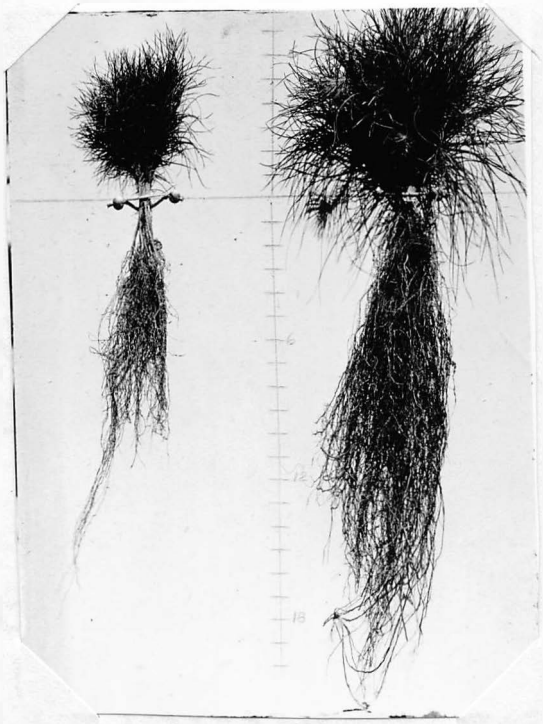

Fig. 4.